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Hydrangea Cultivation: Advances in Propagation, Soil Management, and Disease Control

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Abstract

Hydrangeas, prized for their showy blooms, encompass diverse shrubs, small trees, and climbers within the Saxifragaceae family. This review comprehensively examines various aspects of hydrangea cultivation, focusing primarily on Hydrangea macrophylla. Originating from temperate regions of eastern Asia, eastern North America, and South America, hydrangeas are popular globally, especially as potted plants during festive seasons. Their large flower heads exhibit a range of colors influenced by soil pH, particularly in Hydrangea macrophylla, where aluminum availability in acidic soils (pH 4.5-5.5) results in blue hues, while higher pH (6.0-7.0) produces pink flowers. The review details optimal climatic conditions, including semi-shade and cool, moist temperatures, with specific temperature requirements for flower initiation and bud development. Soil preferences, propagation methods (seeds, cuttings, layering, and micropropagation), planting guidelines, fertilization strategies (including the impact of NPK ratios and slow-release fertilizers), and pest and disease management are discussed. The importance of cultural control methods, such as proper cultivation, fertilization, irrigation, and sanitation in minimizing disease incidence is emphasized. Common diseases like anthracnose, leaf spot, powdery mildew, bacterial wilt, bud blight, and Botrytis infection are described, along with appropriate control measures. The review concludes by highlighting the importance of understanding these factors for successful hydrangea cultivation and production.

Keywords: *Hydrangeas, cultivation practices, quality production*

Introduction

Hydrangeas, often hailed as the "Queen of the Flowering Shrubs," comprise a diverse genus of evergreen and deciduous shrubs, small trees, and even woody climbers. Belonging to the Saxifragaceae family, these captivating plants are renowned for their showy flower heads and are prized possessions in gardens across Europe, North America, and Asia [6]. Thriving in temperate climates with ample moisture, hydrangeas boast a global appeal, consistently ranking among the top ten flowering pot plants, particularly during festive seasons like Easter and Mother's Day. Characterized by their large, vibrant flower heads, hydrangeas display a spectrum of colors, including white, red, purple, pink, and blue. Their foliage is equally enchanting, featuring beautiful oval to circular leaves with wavy edges and prominent veins. The star-shaped flowers, often sterile, are arranged in clusters known as corymbs or panicles.

The genus encompasses approximately 25 hardy species, with prominent members including *H. macrophylla*, *H. arborescens*, *H. serrata*, *H. paniculata*, and *H. quercifolia*. A comprehensive taxonomic description of hydrangeas was provided by [16], identifying 23 species with a diverse geographical distribution across temperate and tropical regions of eastern Asia, eastern North America, and South America. While boasting a rich natural diversity, *H. macrophylla* cultivars exhibit limited genetic variation due to their restricted native range and the impact of breeding programs with overlapping objectives [9],[22]. Today's cultivars largely descend from plants developed during the early 20th century through controlled crosses, open pollination, or the selection of unique branches (sports) from wild-collected germplasm. *H. macrophylla* stands as a particularly celebrated species, widely cultivated both as a vibrant potted plant for indoor enjoyment and as a stunning deciduous shrub that graces landscapes worldwide [3[,[6].

Beyond their ornamental value in gardens, hydrangeas have also gained significant popularity as cut flowers. Renowned for their vibrant hues, they boast the most intense color spectrum among hydrangea species, extending beyond the traditional pinks and blues [4]. Historically, hydrangea cultivation primarily focused on the spring pot plant market in established floriculture nations. However, cultivating hydrangeas has emerged as a highly profitable endeavor, mirroring the success of other prominent cut flower crops like roses, chrysanthemums, and carnations. As flowering pot plants, hydrangeas can be produced year-round, catering to consistent demand. The economic impact of hydrangea cultivation is substantial. In the United States alone, over 1,500 nurseries were involved in hydrangea production, with annual sales exceeding 10 million plants. This significant market share accounted for 13.5% of the total annual U.S. shrub sales, translating to a substantial economic value of $91.2 million

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within the broader $676.6 million shrub market [21].

a) Hydrangea macrophylla *b) H. panniculata*

H. macrophylla: Commonly known as Bigleaf, Garden, or Mophead hydrangeas, *Hydrangea macrophylla* is a beloved deciduous shrub renowned for its large, showy flower heads. These vibrant blooms typically grace gardens from May to early July, adding a burst of color to summer landscapes. While the initial flowering period may fade, some reblooming varieties offer a second wave of blooms in the fall. Mophead varieties feature rounded, globe-like clusters of flowers, while lace-cap varieties exhibit a more delicate appearance with a ring of larger, showy outer petals surrounding a central cluster of smaller flowers. Flower colors can range from vibrant blues and purples to soft pinks, reds, and whites. Soil pH plays a significant role in determining flower color in some varieties [1].

Popular Cultivars:

1. 'All Summer Beauty': Known for its continuous blooming throughout the season.
2. 'Bloom-struck': A reblooming variety with vibrant blue flowers.
3. 'Blushing Bride': Produces large, rounded clusters of pink flowers.
4. 'Blue Danube': Features stunning blue flowers that can change color depending on soil pH.
5. 'Blue Wave': Another popular variety with blue flowers that can be influenced by soil acidity.
6. 'Endless Summer': A well-known reblooming series with a wide range of flower colors.
7. 'Everlasting Queen': Offers long-lasting blooms and a compact growth habit.
8. 'Forever & Ever': A reblooming series with excellent winter hardiness.
9. 'Lady in Red': Produces vibrant red flowers.
10. 'Merritt's Supreme Pink': Known for its large, deep pink flower heads.
11. 'Lemon Zest': Features unique chartreuse-green flowers that mature to pink.
12. 'Painter's Pallet': Offers a mix of colors within each flower head.
13. 'Tokyo Delight': A compact variety with large, vibrant blue flowers.

H. panniculata: Commonly known as panicle hydrangeas, is a captivating deciduous shrub or small tree native to East Asia, gracing gardens with its stunning late-summer blooms. These elegant plants are prized for their large, cone-shaped flower panicles that emerge in shades of white and gradually mature into captivating hues of pink, red, or even burgundy as the season progresses [20]. The defining characteristic of *H. paniculata* is its impressive flower panicles, often reaching significant size and boasting a mix of fertile and sterile florets. Popular Cultivars:

1. 'Grandiflora': A classic variety with large, cone-shaped panicles of white flowers that age to pink.
2. 'Limelight': Showy, chartreuse-green flowers that mature to a deep pink in fall.
3. 'Pink Diamond': Produces large, conical panicles of vibrant pink flowers.
4. 'Phantom': Known for its exceptionally large, white flower panicles.
5. 'Silver Dollar': Features large, rounded flower heads with a silvery-white appearance.
6. 'Summer Snow': Produces abundant, pure white flowers that create a stunning summer display.
7. 'Vanilla Strawberry': Offers a delightful combination of white and pink flowers.

H. quercifolia: Commonly known as the Oakleaf Hydrangea and as the name suggests, *H. quercifolia* boasts large, lobed leaves that resemble those of oak trees. These leaves often display vibrant fall colors, ranging from deep burgundy to vibrant crimson. The large, cone-shaped flower panicles typically emerge in shades of white or cream and gradually mature to shades of pink or even burgundy as the season progresses. The inflorescences feature a combination of showy, sterile florets and smaller, fertile flowers, creating a visually appealing display. It typically flowers later than many other hydrangea species, with blooms appearing in early to mid-summer and often lasting well into the fall. While preferring acidic soil, *H. quercifolia* is generally adaptable to various soil conditions and thrives in both full sun and partial shade.

Popular Cultivars:

1. 'Snow Queen': Features large, white flower panicles.
2. 'Pee Wee': A compact cultivar with smaller leaves and flower panicles.
3. 'Harmony': Offers a unique combination of white and pink flowers.
4. 'Ruby Slippers': Known for its vibrant fall foliage.

Garden Uses: Hydrangea species are versatile garden plants. They can be used as:

1. Specimen shrubs: To create a focal point in the landscape.
2. Hedge plants: To create a colorful and low-maintenance hedge.
3. Container plants: To add beauty to patios and decks.
4. Cut flowers: To bring the beauty of the garden indoors.
5. Mixed Borders: Its versatility allows it to be incorporated seamlessly into mixed borders and shrubbery plantings.
6. Woodland Gardens: Some species have adaptability to shade makes them well-suited for woodland gardens.

Climatic conditions: *H. macrophylla* is a well-known cultivar. Hydrangeas can thrive in a semi-shady environment. A chilly, damp temperature is thought to be beneficial to growth and development. In India, it is primarily produced as a pot plant or for cut flowers in mountainous locations such as Kashmir, Kalimpong, Darjeeling, Shillong, Himachal Pradesh, Uttarakhand, and others [4]. From early spring through late October, the flowers can be produced. It is unable to withstand high temperatures. Warmer temperatures are required for species like *H. arborescens* cv. 'Anabelle' to acquire maximum aesthetic expression. Morning sun and afternoon shade are preferred by the bigleaf hydrangea. A temperature of 20^0C promotes flower initiation and a temperature between 15-20^0C is required for flower bud development.

For the production of potted plants of *H. macrophylla* extra lighting and heating is necessary, it is profitable for very early market [18]. Adequate early development and bud initiation a minimum of 18^0C night temperature with the short day length of 8 hours for at least 6 weeks is required.

Soil: It can be grown on wide range of soil. *H. macrophylla* grow well in peat and peat/clay mixtures with pH 4.2 to 6.5. *Hydrangea macrophylla's* flower color changes from deep blue to hot pink according on soil pH. When the soil pH is acidic (4.5-5.5), the hue will be blue due to the presence of aluminum [15]. A pH of 6.0 to 7.0 produces a pink floral hue. Flowers at pH levels of 5.5 to 6.5 can be pink, blue, lavender, or a combination of these.

Propagation: Hydrangea species can be propagated by seeds, cuttings and micropropagation. Commercially, propagated through cuttings. Generally, soft wood cuttings collected from early in season (May) will give good and fast growing plants than those cuttings which were collected in late summer (July) [13]. Cuttings can be planted in sand peat medium or then shifted to pots containing a mixture of three parts of loamy soil, 1 part compost manure and 1 part leaf mould. Cuttings can be treated with rooting hormones like IBA, NAA for better rooting quality and shoot development by dip method or as overhead foliar application. *Hydrangea macrophylla* and its cultivars are propagated as rooted cuttings. Softwood cuttings root easily using 1000 ppm IBA [7], [14]. Most of our producers buy their liners from liner producers rather than root their own. They will be 4-6 inches tall when lined out. *Hydrangea quercifolia's* propagation is simple with softwood cuttings and 5000 ppm IBA. However, the first winter may be challenging for survival. *Hydrangea arborescens* are easy to root from softwood cuttings using 1000 ppm IBA [2].

Fig. 2. Terminal soft wood cutting of hydrangea in mist cambers

Seed propagation of hydrangeas, while a viable option for breeding programs, is a labor-intensive process. Hydrangea seeds are minute, requiring careful collection from mature seed capsules in late autumn or early winter. The seed capsules are smashed, and any remaining garbage is removed from the seeds. Sowing is done extremely carefully and evenly on a flat surface, and it is kept moist in a greenhouse or high-humidity enclosure where the temperature may be adjusted [10]. The seeds will germinate in 10-30 days. However, the germination time varies with species like *H. macrophylla* sown in milled sphagnum moss germinated in 2-3 weeks *H. quercifolia* seeds sown directly after collection germinated within 2 weeks. Germination rates vary between species, with some germinating within 2-3 weeks while others may take up to 30 days. Factors such as species, seed quality, and environmental conditions significantly influence germination success. Due to its labor-intensive nature, seed propagation is generally less common than vegetative propagation methods like cuttings or grafting for most hydrangea cultivars.

Layering can also be used to propagate big-leaf hydrangea. This is accomplished by digging a hole near the plant and bending a segment of limb down into it. Remove a small ring of outer bark about 1 inch wide all the way around the limb where it contacts the earth with a knife. Cover the limb with earth, leaving 6 to 12 inches of tip growth exposed. If you layer during the summer, the new plant should be ready for transplanting the following winter.

Flowering: While most cultivars bloom in early summer, others may continue to bloom throughout the season. Crop head or Hortensia cultivars produce enormous circular corymbs with mostly sterile flowers whereas lace-cap cultivars produce flattened inflorescences with an outer ring of sterile flowers and an inner ring of small fertile flowers. Flower color varies according to soil pH. Some varieties do not produce blue blooms, regardless of pH [17].

Planting: Hydrangeas are typically planted in early spring. Planting distance varies significantly depending on the specific species and cultivar, as well as the soil and environmental conditions. Optimal growth and flowering are achieved in well-drained, moist, and fertile soil rich in organic matter, such as sandy loam or loam with a generous amount of humus. Prior to field planting, thorough soil testing is essential to ensure optimal growing conditions. For container-grown hydrangeas, a well-balanced potting mix is crucial. A recommended mixture for container cultivation includes a blend of forest soil, garden soil, and vermicompost in a ratio of 2:1:1 (v/v) to promote vigorous growth, abundant blooming, and an attractive appearance.

Fertilizer: Hydrangea gives good response to good nutrition. The use of fertilizer in hydrangea is very important as it influence the color of sepals as the sepals contain red anthocyanin pigments that react with Aluminium and certain other elements to give blue color. The color is also influenced by nitrogen like element [19]. The color change depends on concentration of nitrogen as medium to high level will give red color and low level will give mauve color. The application of fertilizers should be in adequate amount in soil or in water for better growth and healthy development [5]. Hydrangeas grow best in soil or media with pH 5.5-6.5. The recommended dose of fertilizer for production of hydrangea is nitrogen 80g/m^2, potassium 50g/m^2. The fertilizers however can be applied in different concentration according to the type of fertilizer i.e., liquid or granules. Also, as inorganic and organic fertilizers. Hydrangea thrives best in a balanced ratio of NPK 10-10-10 or 10-4-8 NPK. It is also noted that to increase size and quality of blooms more phosphorous is effective. Fertilizer with the NPK 10-20-10 can also be used. When applying fertilizer, be careful not to apply too much, as excessive nitrogen levels can promote more leaf and stem growth and less blossom growth [23]. The use of slow-release fertilizer has been shown to be largely effective. Early spring and late fall are the times for application. For a more beneficial effect, apply granular fertilizer around the base and then rake it in. In case of liquid fertilizers the concentration needs to be dissolved in water first than applied as foliar spray on plants. This method is more useful as the rate of nutrient absorption is more and is fast acting. An application of 10-15g/pot of Nitrogen (CRF) is effective in improving plant quality and flowering time.

Typically, a medium to high rate of controlled released fertilizers are top dressed, applied at the time of planting and again in summers (depending on fertilizer longevity and production cycle). The use of urea-formaldehyde during potting assures nitrogen availability to the plant and maintains the soil's subsequent electrical conductivity. Urea foliar treatment in the fall, prior to leaf loss and dormancy, increases nitrogen levels in the plant. It is also possible to use gypsum or dolomite to add calcium to the soil in order to alter the pH (if pH adjustment is not done).

Irrigation: *H. macrophylla* is a heavy water user that wilts readily in dry conditions; nevertheless, there are differences amongst cultivars. When cultivated in pots outdoors in 40 percent shade, the average daily water use of 7- 7.8 fl. oz. However, some species consumed around 4.5-5.0 gallons of water over a two and a half month period. However, there are potential to improve irrigation applications, as this species' reputation as a heavy water user appears to encourage over-irrigation.

Pruning: Pruning is an important operation in hydrangea to maintain flower quality and vigour of the plant. It is also done to give a definite shape to the plants. *Hydrangea macrophylla* requires light pruning like cut out of thin, twiggy growth and older flower heads, leaves. Also, crowded and weak branches should be removed. Usually, this is done in spring in order to encourage the growth of new flowering stems. Pruning and pinching are very important production techniques to reduce size, enhance flowering and stimulate lateral branches. But these two practices are costly and need intense labor work. If not done properly, it will affect the growth of hydrangea [11]. Post-planting care should be carefully done like weed management, keeping proper moisture in the soil should be carefully done. Frequent watering in summer should be done, as high temperature causes wilting. In containers hydrangeas are considered high users of water, about 8 to 10 gallons of water is utilized by the plant for a period of 6 months.

Hydrangea species	Pruning time
Hydrangea macrophylla	Done always before August, after flowering in July.
Hydrangea quercifolia	Plants does not usually need pruning. If reshaping or size-reduction is necessary, prune after blooms begin to fade.
Hydrangea paniculata 'Grandiflora'	Prune entire plant back to 6-12" in March. Plant blooms on current year's wood. Or leave unpruned – blossoms will appear on new growth.
Hydrangea arborescens 'Annabelle'	Prune entire plant back to 6-12" from ground around March 1st. Plant blooms on current year's wood.
Hydrangea anomala petiolaris	May not need pruning, except to shape. Prune after bloom.

Failure to bloom can be caused by any or all of the following factors [12].

- The plant is still in its infancy i.e., it is still immature.
- Frost damage to flower buds in the winter/early spring.
- Pruning late in the summer.
- There is far too much shade.
- Nitrogen fertilizer in excess.

Insect Pests and Diseases: Insect pests such as weevils, caspids bugs, aphids, scale, and chafer beetle may infest the plants. Weevils (*Otriorynchus sulcatus*) cut notches in leaf edges, and chafer beetle (*Macrodactylus* sp.) grubs eat roots and stems near the ground level, slowing growth. These insects are controlled by spraying with Nuvacron (0.05%).

Aphids (*Aphis gossypii*) and scale insects (*Pulvinaria* sp.) suck plant sap from tender leaves, shoots and flower buds, reducing the plant's overall vitality. The application of dimethoate @ 0.03% is efficient in controlling these insects. Caspids bugs (*Lygus rugulipennis*) damage young leaves by piercing them with numerous little holes. A spray of Dimethoate @ 0.03% is helpful in controlling the infestation.

Cultural control methods improve plant health by employing good horticulture methods such as adequate cultivation, fertilization, irrigation, and sanitation. Providing ideal circumstances for optimal plant growth and development will lessen plant stress, lowering the probability of disease occurrence.

Hydrangea commonly suffers from diseases like:

1. Anthracnose (*Colletotrichum gloeosporioides, Colletotrichum dematium)* which causes small dark brown or black circular spots on younger leaves and soon the spots start forming one big spot to spread over larger areas. Wet weather promotes this disease, and hydrangeas that have been heavily fertilized are more prone to it. Splashing water spreads the fungal spores to leaves and flowers. Frequent rain, dew, and prolonged heavy fog encourage infection and symptom development. Infected hydrangeas are the primary source of the anthracnose fungus. A spray of Bavistin @ 0.1% is found effective against anthracnose.

2. Powdery mildew [Causal agents: *Golovinomyces orontii* (formerly *Erysiphe polygoni*), *Erysiphe poeltii*, *Microsphaera friesii*, *Oidium hortensiae*] which appears on the foliage first as greyish white spots and keeps on increasing its size to finally form a powdery mass; crinkled, curled and stunted growth of severely affected leaves; bacterial wilt and bud blight can also be seen. Prevent powdery mildew on plants by improving airflow, lowering humidity (if you can), and removing dead plant material. Fungicides work best when applied preventatively, before the disease appears [8].

3. Botrytis infection of floral buds is also found in hydrangeas. Caused by *Botrytis cinerea.* Suitable conditions for the development of Botrytis blight are several days of cloudy, humid and rainy weather. Small water-soaked spots are often observed on hydrangea flower petals, which quickly expand into reddish brown irregular blotches and are often covered with *B. cinerea* sporulation [8]. Controlling Botrytis blight needs a multi-pronged approach, including sanitation, good growing practices, and preventative fungicide sprays. Start by thoroughly cleaning benches and growing areas before introducing new plants. Regularly remove any infected plants, flowers, and debris. Disinfect tools and surfaces, especially in propagation and production areas. Use disease-free cuttings for propagation and handle them carefully to avoid injuring the plant tissue. Proper watering, good ventilation, lower humidity, and blocking UV light can all help prevent Botrytis spores from germinating and causing infection.

4. Cercospora Leaf Spot caused by *Cercospora hydrangea.* It is a serious disease affecting hydrangeas in both gardens and nurseries, impacting most varieties. It's particularly common in low-maintenance plantings. The disease starts with small, circular brown or purple spots on lower leaves. On bigleaf hydrangeas, these spots develop a light gray center with a brown or purple ring around them. On the oakleaf hydrangea these spots appear angular in shape and are dark brown to purple in color. Managing Cercospora leaf spot involves strategies like enduring drought periods, removing diseased leaves, using nitrogen fertilizer, and watering at the base of the plant (like with drip irrigation). Fungicides are generally not recommended for late-season infections. However, they can be helpful if applied as soon as leaf spots appear. Multiple fungicide applications are necessary for good control [8].

Nutritional deficiency symptoms

Nitrogen: It is an essential plant nutrient that is often deficient. The plant's elder leaves begin to yellow, a condition known as chlorosis and black to brown necrotic tips may become visible. Young leaves have crimson borders, and bud scales could be purple.

Phosphorous: The lowest older leaves have consistent yellow and sometimes purple edges. The plant's growth is limited because of the deficit, which causes internode shortening and a decrease in flower buds. Additionally, new growth may be smaller and have a dark or blue green hue.

Potassium: Its absence leads the shoot to form a rosette as the internodes shorten to form a compact look. The elder leaves first turn yellow, and subsequently the plant tissues die due to fast necrosis.

Sulphur: It causes chlorosis **(**yellowing**)** in younger or recently expanded leaves which can also be marked on leaf margins too. There is reduction in shoot length, short internodes thus causing retarded growth. Deficiency also leads to leaf drop. It has similar symptoms to that of nitrogen symptoms.

Iron: low level of iron in the soil causes chlorosis of the foliage or poor rot growth. For this Iron sulphate can be used. It can be confused with manganese (Mn) deficiency.

Calcium: The symptoms first appear in younger leaves as it is immobile in plants. The leaves will appear light green yellow to translucent, necrosis of young growth can be seen.

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